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(54) **Pumping heat using lubricated compressor**

(57) Heat is pumped by a processor using a vapour-compression heat pump comprising a lubricated compressor, a condenser, an expansion valve, an evaporator and a refrigeration fluid (e.g. a halocarbon) wherein the lubricating oil has a minimum kinematic viscosity of 20 cSt at 100°C and comprises at least a major proportion by weight of a mineral oil. The lubricating oil may comprise 60 to 90 wt.% of mineral oil and 40 to 10 wt.% of a thickener, e.g. polybutene.

SPECIFICATION

A process for pumping heat

- 5 This invention relates to a process for pumping heat using a vapour-compression heat pump. 5
- The urgent necessity for energy savings through better use of available natural resources has recently resulted in new incentives for the development of heat pumps in industry. This has also led to lubrication problems, especially with heat pumps having condensation temperatures above 60°C. Such heat pumps require lubricants having excellent thermal stability in the presence of the less volatile refrigerants as well as
- 10 sufficient viscosity to counter balance the inevitable drop of viscosity due to dilution by the refrigerant. 10
- At the moment lubricants which are available for heat pumps operating at high temperature are hydrogenated poly alpha-olefin synthetic oils. We have now discovered a process of pumping heat using a heat pump wherein the lubricant is considerably cheaper and has better stability in the presence of hot refrigerants than the hydrogenated poly alpha-olefin synthetic oils.
- 15 According to this invention heat is pumped using a vapour-compression heat pump comprising a lubricated compressor, a condenser, an expansion valve, an evaporator and a refrigeration fluid wherein the lubricating oil has a minimum kinematic viscosity of 20 cSt at 100°C and comprises at least a major proportion by weight of a mineral oil. 15
- In the vapour-compression heat pump, the compressor compresses gaseous refrigerant fluid which then
- 20 passes to the condenser. In the condenser the gas condenses and the latent heat of condensation is delivered to the load, usually by heat exchange. The condensed refrigerant then passes to the expansion valve where it expands, its pressure decreasing. The expanded liquid refrigerant then passes to the evaporator where it evaporates, absorbing heat from the low temperature heat source. The evaporated refrigerant then returns to the compressor where the cycle repeats itself. 20
- 25 In this manner with a high temperature heat pump it is possible to pump heat from 50°C to about 130°C, e.g. from about 75°C to 130°C, at the condenser. 25
- The refrigeration fluid is preferably a halocarbon, and more preferably fluorochlorinated hydrocarbons. Examples of suitable fluoro-chlorinated halocarbons are 1,2 dichloro-1,1,2,2 tetrafluoro ethane, dichloro difluoro methane, monochloro difluoro methane, trichloro monofluoro methane, monochloro trifluoro
- 30 methane, 1,1,2 trichloro-1,2,2-trifluoro ethane and tetrafluoro methane. Other refrigerants which may be used include methylene chloride, methyl chloride, trichloro methane, ammonia, and the common azeotropic mixtures of the above-mentioned refrigerants. 30
- The lubricating oil having a minimum kinematic viscosity of 20 cSt at 100°C comprises at least a major proportion by weight of a mineral oil. It is possible therefore for the lubricating oil to be 100% mineral oil.
- 35 However in general it is preferred that the lubricating oil should comprise 60% to 90% by weight of a mineral oil and 40% to 10% by weight of a thickener, and more preferably 70% to 90% by weight of a mineral oil and 30% to 10% by weight of a thickener. 35
- Various mineral oils may be used. One could use a paraffinic distillate having a kinematic viscosity of between 10 and 15 cSt at 100°C, a viscosity index of between 90 and 100 and a flash point of at least 250°C.
- 40 Such paraffinic distillates would however have to be used with a thickener because the kinematic viscosity of the distillate itself is not high enough. In general one can use petroleum oil fractions ranging from naphthas, spindle oils to SAE 30, 40 or 50 lubricating oil grades, with the proviso that a thickener will be necessary if the kinematic viscosity of the mineral oil alone is less than 20 cSt at 100°C. It is preferred that the mineral oil alone has a kinematic viscosity of at least 20 cSt at 100°C. The molecular weight of the mineral can typically
- 45 be between 400 and 700. 45
- The thickener is preferably a substantially saturated hydrocarbon polymer, especially a polymer of an olefin, e.g. polyethylene, polypropylene or especially polybutylene or polyisobutylene. Preferably the average molecular weight of the olefin polymer should be fairly low, preferably between 1,000 and 27,000, e.g. between 3,000 and 25,000 and the polymer should be liquid at ambient temperature which means a
- 50 maximum of about 27,000 for polybutene polymers. 50
- The lubricating oil has a minimum kinematic viscosity of 20 cSt at 100°C and often this kinematic viscosity will be higher, e.g. between 30 and 45 cSt at 100°C. Three typical lubricating oils suitable for use in the present invention have the following characteristics:

	A	B	C	
	Kinematic Viscosity at 40°C (cSt)	236	453	650
5	Kinematic Viscosity at 100°C (cSt)	21.2	31.9	40.2
	Viscosity Index	106	102	101
10	Flash Point COC (°C)	260	260	260
	Density at 15°C (kg/m ³)	873	877	879
	Pour Point (°C)	24	-24	-21
15	Cloud Point (°C)	-20	-20	-20
	Floc RF 12 (°C)	-39	-36	-36
20	Aniline point (°C)	130	137	140
	Acid number (mgKOH/g)	0.02	0.02	0.02
	Colour ASTM D 1500	water white	water white	water white

25 The lubricating oils A, B and C have the following contents of oil and polybutene thickener: 25

	A	B	C	
30	Mineral oil	76	64	57
	Polybutene thickener	24	36	43

It is preferred that the lubricating oil has a viscosity index of between 90 and 115 and especially between 100 and 110.

35 Normally it is not necessary to include other additives, such as VI improvers or antioxidants, in the lubricating oil. 35

In the presence of refrigerants, such as halocarbons, it has been found that the thermal stability of the lubricating oils used in the process of the invention is excellent. Also these lubricating oils provide excellent protection against the wear of metal parts and a remarkable safety of operation in the most severe temperature conditions. 40

Thermal and chemical stability tests

Lubricating oils used in the process of the invention were evaluated for their thermal and chemical stability in the presence of refrigerants.

45 The lubricating oil was blended with different fluorocarbon refrigerants at two different concentrations and held in sealed tubes for 7 days, 2000 hours and 4000 hours at 165°C in the presence of copper, iron and aluminium strips. The longer the time the darker the oil became, but the more stable the oil the less the darkening. In addition to the visual rating the total acid number of the used oils was measured for each tube. The lubricating oil was compared with a commercially available lubricant and the results obtained were as follows: 50

*Total acid number of used oils
after sealed tube tests
(mgKOH/g)*

5	Lubricating Oil	Oil Concen- tration in refrig- erant (%)	Refrigerant	Test duration			5
				7 days	2000 h	4000 h	
10							10
		10	CCl ₂ F ₂	1.1	2.4	2.5	
		10	CICF ₂ CF ₂ Cl	0.4	1.2	1.4	
	C	50	CCl ₂ F ₂	0.2	2.0	2.2	
15		50	CICF ₂ CF ₂ Cl	0.1	0.2	0.5	15
		10	CCl ₂ F ₂	1.4	2.9	3.1	
	Commercially	10	CICF ₂ CF ₂ Cl	0.4	1.3	1.5	
	available	50	CCl ₂ F ₂	0.2	2.2	2.4	
20	oil	50	CICF ₂ CF ₂ Cl	0.2	1.0	1.2	20

In general the darkening was always greater for the commercially available oil compared with the lubricating oil C, the composition of which has been given previously.

Field testing on a high temperature heat pump

25 Two tests were carried out on a high temperature vapour-compression heat pump using lubricating oil B, the composition of which has been given previously. 25

In one case the refrigerant which was used was dichloro difluoro methane and the temperature of the evaporator varied from 8° to 32°C and that of the condenser varied from 52 to 80°C. In the second case the refrigerant was 1,2, dichloro-1,1,2,2 tetrafluoroethane and the temperature of the evaporator varied from 40° 30 to 70°C and that of the condenser varied from 80°C to 130°C. 30

It was found that the lubricating oil B was very suitable for use in high temperature heat pumps. Despite the important dilution (10% to 30%) of the oil by the refrigerant the viscosity was still sufficient to ensure a satisfactory lubrication over a very long period of time. Furthermore, the thermal stability of the lubricating oil in the presence of both refrigerants was found to be excellent.

35 Inspections of the lubricating oil were performed after 800 hours, 1500 hours and 2300 hours of operation and the results were as follows: 35

40 *Field testing of lubricating oil B on
high temperature heat pump (with CCl₂F₂)
50°C to 80°C at the condenser* 40

45	Characteristics	New Oil	Degassed Used Oil *			45
		-	800 hours	1500 hours	2300 hours	
	Viscosity (cSt) at 100°C	31.9	28	28	28	
50	Viscosity Index	102	102	102	102	50
	TAN (mgKOH/g)	0.02	0.02	0.02	0.02	
	ASTM colour	water white	0.5-	0.5-	0.5-	
55	Pour point (°C)	-24	-24	-24	-24	55
	Water (ppm)	traces	traces	traces	traces	
60	Sediments	0	0	0	0	60
	Metals (by spectrometer)	traces	traces	traces	traces	
65	*i.e. after complete removal of CCl ₂ F ₂					65

*Field testing of lubricating oil B on
high temperature heat pump with (CICF₂CF₂Cl)
80°C to 130°C at the condenser*

5	Characteristics	New Oil	Degassed Used Oil *			5
		-	900 hours	1500 hours	2300 hours	
	Viscosity (cSt) at 100°C	31.9	23	22	22	
10	Viscosity Index	102	102	102	102	10
	TAN (mgKOH/g)	0.02	0.02	0.02	0.02	
15	ASTM colour	water white	0.5 ⁻	0.5 ⁻	0.5 ⁻	15
	Pour point (°C)	-24	-25	-24	-24	
	Water (ppm)	traces	traces	traces	traces	
20	Sediments	0	0	0	0	20
	Metals (by spectrometer)	traces	traces	traces	traces	
25	*i.e. after complete removal of CICF ₂ CF ₂ Cl					25

It is clear that almost all the principal characteristics of the lubricating oil were unchanged that no sediments or metals are found in the oil, even after 2300 hours of operation.

30 CLAIMS 30

1. A process of pumping heat using a vapour-compression heat pump comprising a lubricated compressor, a condenser, an expansion valve, an evaporator and a refrigeration fluid wherein the lubricating oil has a minimum kinematic viscosity of 20 cSt at 100°C and comprises at least a major proportion by weight of a mineral oil. 35
2. A process according to claim 1 wherein the refrigeration fluid is a halocarbon.
3. A process according to claim 2 wherein the halocarbon is a fluorochlorinated hydrocarbon.
4. A process according to any one of the preceding claims wherein the lubricating oil comprises 60 to 90 wt.% of a mineral oil and 40 to 10 wt.% of a thickener. 40
5. A process according to claim 4 wherein the thickener is a substantially saturated hydrocarbon polymer.
6. A process according to claim 5 wherein the polymer is polyolefin having a molecular weight of between 1,000 and 27,000.